

U.S. ENVIRONMENTAL PROTECTION AGENCY  
NATIONAL AIR AND RADIATION ENVIRONMENTAL LABORATORY  
540 S. MORRIS AVE., MONTGOMERY, AL 36115  
RA226 ANALYSES

REPORT OF SAMPLE DELIVERY GROUP #1200016

Project: Dimock Residential GW Site, Dimock, PA - Follow-up work  
Analysis method: Radium-226 in Water: Rapid Method for High-Activity Samples  
Report ID: 1200016-RA226  
Report type: Original  
Date reported: 06/14/2012  
Total pages in report: 14

SAMPLES

| NAREL<br>Sample # | Client Sample ID | Location  | Matrix         | Date<br>Collected | Date<br>Received |
|-------------------|------------------|-----------|----------------|-------------------|------------------|
| B2.05495G         | FB22             | PA:DIMOCK | WATER-DRINKING | 05/22/2012        | 05/23/2012       |
| B2.05496H         | HW64             | PA:DIMOCK | WATER-DRINKING | 05/22/2012        | 05/23/2012       |
| B2.05497J         | FB23             | PA:DIMOCK | WATER-DRINKING | 05/23/2012        | 05/24/2012       |
| B2.05498K         | HW63Z            | PA:DIMOCK | WATER-DRINKING | 05/23/2012        | 05/24/2012       |
| B2.05499L         | HW62             | PA:DIMOCK | WATER-DRINKING | 05/22/2012        | 05/24/2012       |
| B2.05500K         | HW63             | PA:DIMOCK | WATER-DRINKING | 05/23/2012        | 05/24/2012       |

EXCEPTIONS

1. **Packaging and shipping** – No problems were observed.
2. **Documentation** – No problems were observed.
3. **Sample preparation** – No problems were encountered.
4. **Analysis** – No problems were encountered.
5. **Holding times** – No holding times were specified.

QUALITY CONTROL

1. **QC samples** – All QC analysis results met NAREL acceptance criteria.
2. **Yields** – All chemical yields were within acceptance limits.
3. **Instruments** – Response and background checks for all instruments used in these analyses met NAREL acceptance criteria.

## CERTIFICATION

I certify that this data report complies with the terms and conditions of the Quality Assurance Project Plan, except as noted above. Release of the data contained in this report has been authorized by the Director of the Center for Environmental Radioanalytical Laboratory Science and the NAREL Quality Assurance Manager, or their designees, as verified by the following signatures.

Mary Wisdom 6-18-12  
Mary F. Wisdom Date  
Quality Assurance Manager, NAREL

Cynthia White 6-18-12  
Cynthia A. White Date  
Acting Director, Center for Environmental Radioanalytical  
Laboratory Science

## GENERAL INFORMATION

### SAMPLE TYPES

|     |               |
|-----|---------------|
| BLD | Blind sample  |
| FBK | Field blank   |
| SAM | Normal sample |

### ANALYSIS QC TYPES

|     |  |
|-----|--|
| ANA | Normal analysis  |
| DUP | Laboratory duplicate   |
| LCS | Laboratory control sample (blank spike)                            |
| MS  | Matrix spike   |
| MSD | Matrix spike duplicate   |
| RBK | Method blank   |
| STD | External standard (used for $^{228}\text{Ra}$ yield determination) |

### QUALITY INDICATORS

|     |   |
|-----|---|
| RPD | Relative Percent Difference   |
| %R  | Percent Recovery  |
| Z   | Number of standard deviations by which a QC measurement differs from the expected value |

### RADIOCHEMICAL DATA

Radiochemical analyses usually require the subtraction of an instrument background measurement result from a gross sample measurement result. Both values are positive, but when the sample activity is low, random variations in the two measurements can cause the gross value to be less than the background, resulting in a measured activity less than zero. Although negative activities have no physical significance, they do have statistical importance, as for example in the evaluation of trends or the comparison of two groups of samples.

To the extent practical, it is the policy of NAREL to report results as generated, whether positive, negative, or zero, together with the "2-sigma" measurement uncertainty and a sample-specific estimate of the minimum detectable concentration (MDC). The measurement result, uncertainty, and MDC are always expressed in the same unit of measurement.

### EVALUATION OF QC ANALYSES

A method blank result is considered unacceptable if it is more than 3 standard deviations below zero or more than 3 standard deviations above a predetermined upper control limit. For some analyses NAREL has set the upper control limit at zero. For others the control limit is a small positive number.

NAREL evaluates the results of duplicate and spike analyses using "Z scores." A Z score is the number of standard deviations by which the QC result differs from its ideal value. The score is considered acceptable if its absolute value is not greater than 3.

The Z score for a spiked sample is computed by dividing the difference between the measured value and the target value by the combined standard uncertainty of the difference.

The Z score for a duplicate analysis is computed by dividing the difference between the two measured values by the combined standard uncertainty of the difference. When the precision of paired MS/MSD analyses is evaluated, the native sample activity is subtracted from each measured value and the net concentrations are then converted to total activities before the Z score is computed.

Each standard uncertainty used to compute a Z score includes an additional fixed term to represent sources of measurement error other than counting error. This additional term is not used in the evaluation of method blanks.

NAREL reports the "relative percent difference," or RPD, between duplicate results and the "percent recovery," or %R, for spiked analyses, but does not use these values for evaluation.

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**SDG #1200016**

**ANALYSIS SUMMARY**

Analysis method: NAREL RA226-EICHRM  
Title: Radium-226 in Water: Rapid Method for High-Activity Samples

| NAREL Sample #  | Client Sample ID | QC Type | Date Completed | Preparation Batch # | Assay Batch # |
|-----------------|------------------|---------|----------------|---------------------|---------------|
| B2.05495G       | FB22             |         | 06/14/2012     | 0008827N            | 0016042T      |
| B2.05496H       | HW64             |         | 06/14/2012     | 0008827N            | 0016042T      |
| B2.05497J       | FB23             |         | 06/14/2012     | 0008827N            | 0016042T      |
| B2.05498K       | HW63Z            |         | 06/14/2012     | 0008827N            | 0016042T      |
| B2.05499L       | HW62             |         | 06/14/2012     | 0008827N            | 0016042T      |
| B2.05499L       | HW62             | DUP     | 06/14/2012     | 0008827N            | 0016042T      |
| B2.05500K       | HW63             |         | 06/14/2012     | 0008827N            | 0016042T      |
| LCS-00640374Q * |                  | LCS     | 06/14/2012     | 0008827N            | 0016042T      |
| RBK-00640373P * |                  | RBK     | 06/14/2012     | 0008827N            | 0016042T      |

\* Samples marked with an asterisk are not in this sample delivery group but were analyzed with it for QC purposes.

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**SDG #1200016**

**SAMPLE ANALYSIS REPORT**

|                     |                      |                      |                     |
|---------------------|----------------------|----------------------|---------------------|
| Lab sample #:       | B2.05495G            | Amount analyzed:     | 2.000e-01 L         |
| Client sample ID:   | FB22                 | Preparation batch #: | 0008827N            |
| Matrix:             | WATER-DRINKING       | Assay batch #:       | 0016042T            |
| Collected:          | 2012-05-22 11:58 EDT | Prep procedure:      | N/A                 |
| Sample type:        | SAM                  | Analysis method:     | NAREL RA226-EICHROM |
| Dry/wet weight:     | N/A                  | Analyst:             | PH                  |
| Ash/dry weight:     | N/A                  | QC type:             | ANA                 |
| Sample description: | N/A                  |                      |                     |
| Comment:            | N/A                  |                      |                     |

**COUNTING INFORMATION**

| Date and time    | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 06/13/2012 15:48 | 1000.0         | AS73        | GVJ      |

**ANALYTICAL RESULTS**

| Analyte | Activity | $\pm 2 \sigma$<br>Uncertainty | MDC     | Unit  | Reference Date       |
|---------|----------|-------------------------------|---------|-------|----------------------|
| Ra226   | 7.96e-02 | 8.9e-02                       | 1.3e-01 | PCI/L | 06/12/2012 11:53 CDT |

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**SAMPLE ANALYSIS REPORT**

|                     |                      |                      |                     |
|---------------------|----------------------|----------------------|---------------------|
| Lab sample #:       | B2.05496H            | Amount analyzed:     | 2.000e-01 L         |
| Client sample ID:   | HW64                 | Preparation batch #: | 0008827N            |
| Matrix:             | WATER-DRINKING       | Assay batch #:       | 0016042T            |
| Collected:          | 2012-05-22 11:10 EDT | Prep procedure:      | N/A                 |
| Sample type:        | SAM                  | Analysis method:     | NAREL RA226-EICHROM |
| Dry/wet weight:     | N/A                  | Analyst:             | PH                  |
| Ash/dry weight:     | N/A                  | QC type:             | ANA                 |
| Sample description: | N/A                  |                      |                     |
| Comment:            | N/A                  |                      |                     |

**COUNTING INFORMATION**

| Date and time    | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 06/13/2012 15:48 | 1000.0         | AS74        | GVJ      |

**ANALYTICAL RESULTS**

| Analyte | Activity | $\pm 2 \sigma$<br>Uncertainty | MDC     | Unit  | Reference Date       |
|---------|----------|-------------------------------|---------|-------|----------------------|
| Ra226   | 1.73e-02 | 4.8e-02                       | 8.5e-02 | PCI/L | 06/12/2012 12:10 CDT |

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**SAMPLE ANALYSIS REPORT**

|                     |                      |                      |                     |
|---------------------|----------------------|----------------------|---------------------|
| Lab sample #:       | B2.05497J            | Amount analyzed:     | 2.000e-01 L         |
| Client sample ID:   | FB23                 | Preparation batch #: | 0008827N            |
| Matrix:             | WATER-DRINKING       | Assay batch #:       | 0016042T            |
| Collected:          | 2012-05-23 13:25 EDT | Prep procedure:      | N/A                 |
| Sample type:        | SAM                  | Analysis method:     | NAREL RA226-EICHROM |
| Dry/wet weight:     | N/A                  | Analyst:             | PH                  |
| Ash/dry weight:     | N/A                  | QC type:             | ANA                 |
| Sample description: | N/A                  |                      |                     |
| Comment:            | N/A                  |                      |                     |

**COUNTING INFORMATION**

| Date and time    | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 06/13/2012 15:48 | 1000.0         | AS77        | GVJ      |

**ANALYTICAL RESULTS**

| Analyte | Activity | $\pm 2 \sigma$<br>Uncertainty | MDC     | Unit  | Reference Date       |
|---------|----------|-------------------------------|---------|-------|----------------------|
| Ra226   | 2.97e-02 | 6.3e-02                       | 1.1e-01 | PCI/L | 06/12/2012 12:02 CDT |

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**SAMPLE ANALYSIS REPORT**

|                     |                      |                      |                     |
|---------------------|----------------------|----------------------|---------------------|
| Lab sample #:       | B2.05498K            | Amount analyzed:     | 2.000e-01 L         |
| Client sample ID:   | HW63Z                | Preparation batch #: | 0008827N            |
| Matrix:             | WATER-DRINKING       | Assay batch #:       | 0016042T            |
| Collected:          | 2012-05-23 13:10 EDT | Prep procedure:      | N/A                 |
| Sample type:        | SAM                  | Analysis method:     | NAREL RA226-EICHROM |
| Dry/wet weight:     | N/A                  | Analyst:             | PH                  |
| Ash/dry weight:     | N/A                  | QC type:             | ANA                 |
| Sample description: | N/A                  |                      |                     |
| Comment:            | N/A                  |                      |                     |

**COUNTING INFORMATION**

| Date and time    | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 06/13/2012 15:48 | 1000.0         | AS80        | GVJ      |

**ANALYTICAL RESULTS**

| Analyte | Activity | $\pm 2 \sigma$<br>Uncertainty | MDC     | Unit  | Reference Date       |
|---------|----------|-------------------------------|---------|-------|----------------------|
| Ra226   | 2.35e-01 | 1.2e-01                       | 8.4e-02 | PCI/L | 06/12/2012 12:07 CDT |



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**SAMPLE ANALYSIS REPORT**

|                     |                      |                      |                     |
|---------------------|----------------------|----------------------|---------------------|
| Lab sample #:       | B2.05499L            | Amount analyzed:     | 2.000e-01 L         |
| Client sample ID:   | HW62                 | Preparation batch #: | 0008827N            |
| Matrix:             | WATER-DRINKING       | Assay batch #:       | 0016042T            |
| Collected:          | 2012-05-22 15:59 EDT | Prep procedure:      | N/A                 |
| Sample type:        | SAM                  | Analysis method:     | NAREL RA226-EICHROM |
| Dry/wet weight:     | N/A                  | Analyst:             | PH                  |
| Ash/dry weight:     | N/A                  | QC type:             | ANA                 |
| Sample description: | N/A                  |                      |                     |
| Comment:            | N/A                  |                      |                     |

**COUNTING INFORMATION**

| Date and time    | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 06/13/2012 15:48 | 1000.0         | AS82        | GVJ      |

**ANALYTICAL RESULTS**

| Analyte | Activity | $\pm 2 \sigma$<br>Uncertainty | MDC     | Unit  | Reference Date       |
|---------|----------|-------------------------------|---------|-------|----------------------|
| Ra226   | 6.97e-02 | 8.1e-02                       | 1.1e-01 | PCI/L | 06/12/2012 12:06 CDT |

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**SAMPLE ANALYSIS REPORT**

|                     |                      |                      |                     |
|---------------------|----------------------|----------------------|---------------------|
| Lab sample #:       | B2.05499L            | Amount analyzed:     | 2.000e-01 L         |
| Client sample ID:   | HW62                 | Preparation batch #: | 0008827N            |
| Matrix:             | WATER-DRINKING       | Assay batch #:       | 0016042T            |
| Collected:          | 2012-05-22 15:59 EDT | Prep procedure:      | N/A                 |
| Sample type:        | SAM                  | Analysis method:     | NAREL RA226-EICHROM |
| Dry/wet weight:     | N/A                  | Analyst:             | PH                  |
| Ash/dry weight:     | N/A                  | QC type:             | DUP                 |
| Sample description: | N/A                  |                      |                     |
| Comment:            | N/A                  |                      |                     |

**COUNTING INFORMATION**

| Date and time    | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 06/13/2012 15:48 | 1000.0         | AS83        | GVJ      |

**ANALYTICAL RESULTS**

| Analyte | Activity | $\pm 2 \sigma$<br>Uncertainty | MDC     | Unit  | Reference Date       |
|---------|----------|-------------------------------|---------|-------|----------------------|
| Ra226   | 1.05e-02 | 4.7e-02                       | 9.0e-02 | PCI/L | 06/12/2012 12:32 CDT |

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**SAMPLE ANALYSIS REPORT**

|                     |                      |                      |                    |
|---------------------|----------------------|----------------------|--------------------|
| Lab sample #:       | B2.05500K            | Amount analyzed:     | 2.000e-01 L        |
| Client sample ID:   | HW63                 | Preparation batch #: | 0008827N           |
| Matrix:             | WATER-DRINKING       | Assay batch #:       | 0016042T           |
| Collected:          | 2012-05-23 13:09 EDT | Prep procedure:      | N/A                |
| Sample type:        | SAM                  | Analysis method:     | NAREL RA226-EICHRM |
| Dry/wet weight:     | N/A                  | Analyst:             | PH                 |
| Ash/dry weight:     | N/A                  | QC type:             | ANA                |
| Sample description: | N/A                  |                      |                    |
| Comment:            | N/A                  |                      |                    |

**COUNTING INFORMATION**

| Date and time    | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 06/13/2012 15:48 | 1000.0         | AS84        | GVJ      |

**ANALYTICAL RESULTS**

| Analyte | Activity | $\pm 2 \sigma$<br>Uncertainty | MDC     | Unit  | Reference Date       |
|---------|----------|-------------------------------|---------|-------|----------------------|
| Ra226   | 2.11e-01 | 1.2e-01                       | 9.7e-02 | PCI/L | 06/12/2012 12:08 CDT |

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**SAMPLE ANALYSIS REPORT**

|                     |               |                      |                     |
|---------------------|---------------|----------------------|---------------------|
| Lab sample #:       | LCS-00640374Q | Amount analyzed:     | 1.000e+00 SAMP      |
| Client sample ID:   | N/A           | Preparation batch #: | 0008827N            |
| Matrix:             | N/A           | Assay batch #:       | 0016042T            |
| Collected:          | N/A           | Prep procedure:      | N/A                 |
| Sample type:        | N/A           | Analysis method:     | NAREL RA226-EICHROM |
| Dry/wet weight:     | N/A           | Analyst:             | PH                  |
| Ash/dry weight:     | N/A           | QC type:             | LCS                 |
| Sample description: | N/A           |                      |                     |
| Comment:            | N/A           |                      |                     |

**COUNTING INFORMATION**

| Date and time    | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 06/13/2012 15:48 | 1000.0         | AS85        | GVJ      |

**ANALYTICAL RESULTS**

| Analyte | Activity | $\pm 2 \sigma$<br>Uncertainty | MDC     | Unit | Reference Date       |
|---------|----------|-------------------------------|---------|------|----------------------|
| Ra226   | 3.60e+00 | 4.0e-01                       | 1.8e-02 | PCI  | 06/12/2012 12:01 CDT |

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**SAMPLE ANALYSIS REPORT**

|                     |               |                      |                     |
|---------------------|---------------|----------------------|---------------------|
| Lab sample #:       | RBK-00640373P | Amount analyzed:     | 1.000e+00 SAMP      |
| Client sample ID:   | N/A           | Preparation batch #: | 0008827N            |
| Matrix:             | N/A           | Assay batch #:       | 0016042T            |
| Collected:          | N/A           | Prep procedure:      | N/A                 |
| Sample type:        | N/A           | Analysis method:     | NAREL RA226-EICHROM |
| Dry/wet weight:     | N/A           | Analyst:             | PH                  |
| Ash/dry weight:     | N/A           | QC type:             | RBK                 |
| Sample description: | N/A           |                      |                     |
| Comment:            | N/A           |                      |                     |

**COUNTING INFORMATION**

| Date and time    | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 06/13/2012 15:48 | 1000.0         | AS86        | GVJ      |

**ANALYTICAL RESULTS**

| Analyte | Activity | $\pm 2 \sigma$<br>Uncertainty | MDC     | Unit | Reference Date       |
|---------|----------|-------------------------------|---------|------|----------------------|
| Ra226   | 4.87e-03 | 1.0e-02                       | 1.7e-02 | PCI  | 06/12/2012 12:04 CDT |

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**SDG 1200016**

**PREPARATION BATCH SUMMARY**

Preparation batch #: 0008827N  
Analysis method: NAREL RA226-EICHROM  
Preparation procedure: N/A

| NAREL Sample #  | Client Sample ID | Analysis # | QC Type | Yield    | $\pm 2 \sigma$ Uncertainty | Analyst |
|-----------------|------------------|------------|---------|----------|----------------------------|---------|
| B2.05495G       | FB22             | 00638940D  |         | 93.04 %  | 8.35 %                     | PH      |
| B2.05496H       | HW64             | 00638946K  |         | 88.55 %  | 8.06 %                     | PH      |
| B2.05497J       | FB23             | 00638952H  |         | 95.88 %  | 9.16 %                     | PH      |
| B2.05498K       | HW63Z            | 00638973N  |         | 88.54 %  | 8.01 %                     | PH      |
| B2.05499L       | HW62             | 00638958P  |         | 89.20 %  | 8.77 %                     | PH      |
| B2.05499L       | HW62             | 00640372N  | DUP     | 90.72 %  | 8.90 %                     | PH      |
| B2.05500K       | HW63             | 00638964M  |         | 97.55 %  | 9.31 %                     | PH      |
| LCS-00640374Q * |                  | 00640374Q  | LCS     | 92.83 %  | 9.08 %                     | PH      |
| RBK-00640373P * |                  | 00640373P  | RBK     | 101.75 % | 9.68 %                     | PH      |

\* Samples marked with an asterisk are not in this sample delivery group but were analyzed with it for QC purposes.

**QC RESULTS FOR BATCH 0008827N**

| NAREL Sample # | Analysis # | QC Type | Analyte | %R    | RPD   | Z     | Evaluation |
|----------------|------------|---------|---------|-------|-------|-------|------------|
| B2.05499L      | 00640372N  | DUP     | RA226   |       | 147.5 | -1.26 | PASS       |
| LCS-00640374Q  | 00640374Q  | LCS     | RA226   | 107.1 |       | 1.15  | PASS       |
| RBK-00640373P  | 00640373P  | RBK     | RA226   |       |       |       | PASS       |